NOTES ON STELLAR CLASSIFICATION.
II.

In the first series of notes[1] I stated how I was trying to find whether a combination of the meteoritic hypothesis and my system of *chemical* classification of stars into two series of ascending and descending temperatures might land us in a method of detecting *physical* differences. The importance of this inquiry depends upon the fact that any system of *chemical* classification along one line must land us in confusion, seeing that equal or nearly equal temperatures, and therefore chemistry—for chemistry is the child of temperature—mark two very different physical states in the life of a star in its progress from nebula to extinction as a cold solid globe.

In order to show the method of attack I give here a diagram showing my classification and that of Harvard (H.3) based upon chemistry. The Harvard symbols given are those of the type stars used in my classification, but the letters B, F, K, etc., are generally used alone.

The difference in physical state assumed on the meteoritic hypothesis is indicated by the wide dotted curve to represent nebulous conditions at the bottom of the ascending arm, and the firm dark line to represent condensed stars at the bottom of the descending one.

I first deal with the evidence of bright lines in certain chemically classified stars as constituting a difference from the normal stars in which bright lines do not occur. The inquiry will show us the stellar species in which these bright lines occur.

In 1876 I suggested that bright lines in stellar spectra might be added to a dark line spectrum by our spectroscopes revealing to us the presence of a gaseous envelope above the most valid absorbing region.[2] I believe Pickering was the first to see such an envelope, and it has been seen since by others.

How such an envelope can strengthen its story when its temperature is increased is shown in a valuable table given in Miss Cannon's catalogue.[3] There we find eighteen stars in which bright Hβ alone is superposed on the absorption line in eight stars. In the others Hγ is added in ten cases. In six stars we get Hδ added to Hβ and Hγ. In one star we get a fourth line, Hε, added to the preceding three. As lines are added the intensity of the earlier lines is increased. The extreme case is μ Centauri, where the intensity of the hydrogen lines is ε 2, δ 3, γ 6, and β 10. In some cases the bright lines are variable, but the same law holds; the work always begins at the red and decreases towards the violet (Fig. 2).

But this is not all the story. In μ Centauri, where we get the greatest development of the bright hydrogen, there are other lines. All these lines but one are enhanced lines—and of iron!

Among the facts to be borne in mind in considering these questions are those revealed by the recent study of the Madrid photographs of the recent Nova (Geminorum 2), recorded in the last volume of Kensington researches.

The photographs showed a well-marked stage as the Nova cooled down, principally indicated by a bright line near λ 4640 (4639·2); and it was further noted that in previous Novæ the appearance of this line preceded that of the ordinary nebula line near λ 500, and further that it was the brightest line in the whole spectrum where Hβ, Hγ, and λ 4472 were visible.

The 4640 line has been noted in several planetary nebulæ, and among the bright lines of the Wolf-Rayet stars not yet chemically classified.

This line is associated in Novæ and elsewhere with another at λ 4688, not produced by the same substance for the lines vary inversely; it also is frequently seen in the Wolf-Rayet stars.

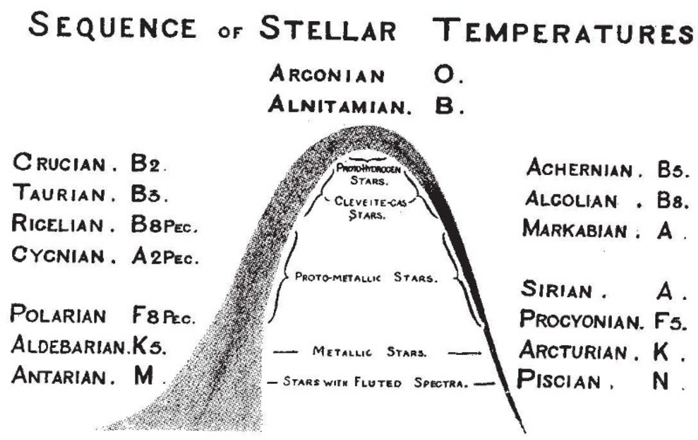

FIG. 1.—The temperature curve.

We seem justified, then, in assuming, to begin with at least, four stages of bright lines:—

H + enhanced lines
H + 4688
H + 4640
lowest temperature H + 500.

and these are common to the stellar envelopes and novæ.

If we include P Cygni, we find another change,

highest temperature H + He + lines of O + N.

Of the substance which produces 4640 we know as yet nothing, but it is possible that 4688 represents carbon, of the existence of which in nebulæ and the Wolf-Rayet stars there is evidence.[4]

On the other hand, in 1905[5] Mr. Baxandall and myself recorded a line at λ 4685·97 in the spectrum of a helium tube, and its occurrence in stars was noted. This would be another origin,

[1] NATURE, November 12, 1914.
[2] See Proc. Roy. Soc., 1878, p. 49.
[3] Harvard Annals, vol. xxviii., part ii., p. 228.

[4] See especially my paper in Proc. R.S., vol. xlvii., p. 40, 1889.
[5] Proc. Roy. Soc., vol. lxxiv., p. 546.

proto-helium. A further inquiry on this subject is necessary, and is under way.

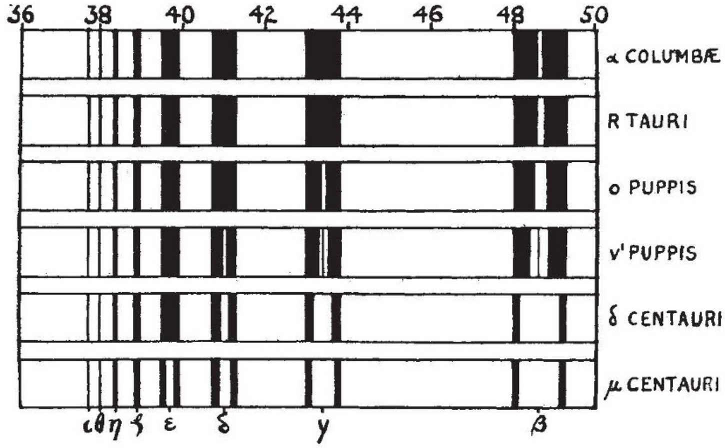

FIG. 2.—Showing how bright hydrogen lines of the stellar envelope make their appearance superposed in the dark absorption lines produced by the subjacent atmosphere or photosphere. This also occurs from the least refrangible side, extending to the blue end as the intensity increases.

It is clear from the above that bright lines have a way of their own, and that the absorption lines and the bright lines have to be studied separately.

It must also be stated that in the majority of non-variable stars with bright lines, the absorption lines have not yet been sufficiently studied to allow of their chemical classification.

I next come to a different origin of bright lines studied in some variable stars. The variability of these is due to a brightening of the continuous spectrum and *the appearance of bright radiations,* at maximum. I have previously (Bull. I.) referred to my hypothesis that these are produced by collisions between meteor swarms.

The simplest case is represented by a swarm B (Fig. 3) revolving round A and colliding at periastron. The light curve of the variability thus produced is represented in the middle part of Fig. 4, a rapid ascent followed by a slower descent, and the curve is smooth.

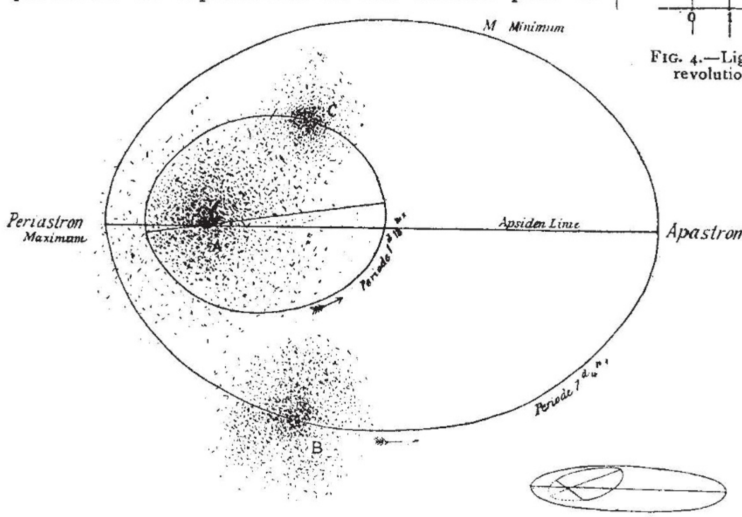

FIG. 3.—Orbits of two meteor swarms B and C round their primary A, colliding at periastron.

The illustrations are taken from Dr. Lockyer's memoir on the variability of η Aquilæ.

In a less simple case, there is a third swarm, C, involved, with a much shorter period than that of B. The combined curve is no longer smooth.

What, then, is the actual physical condition of these two sets of stars with bright lines? In order to answer this question and to test the collision theory in the case of the variables, we must know whether their temperature is rising or falling.

A set of diagrams has been prepared by Mr. N. K. Johnson showing the Harvard and Kensington classifications, the former, except at the bottom, common to the two arms of the temperature curve, which is indicated by two vertical lines and a connecting horizontal line at the top.[6]

To use these we may begin by taking the case of the constant bright line

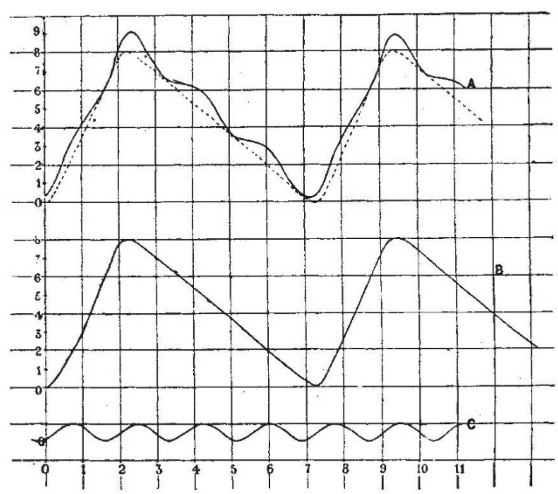

FIG. 4.—Light curves. B, produced by revolution of B; C, produced by revolution of C; A, compound curve produced by both revolutions.

stars, omitting the Wolf-Rayet stars. Of the thirty-eight stars given in the revised Harvard photometry, twelve, indicated by crosses, are included in my classification. All these are near the top of the temperature curve. There is a fair assumption then that the other twenty-six stars may follow suit—that is, that they probably belong to the species which include the twelve; in the absence of a complete classification, therefore, inquiries involving their physical state will be safer in accepting this assumption than in neglecting it.

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[6] The original temperature curve contained gaps below the Cygnian and above the Sirian types for two other possible classes, but these are omitted in the diagrams.